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Determining the Temporal Sampling Frequency of Kis-Balaton and the Spatial Sampling Frequency of Lake Velence (W Hungary) Using Variograms

I. G. Hatvani[1], M. N. Reskóné[2], I. K. Székely[3], P. Tanos[4], J. Korponai[4,5], J. Kovács[1]
[1] Eötvös Loránd University, Department of Physical and Applied Geology, Budapest Hungary
[2] Middle Transdanubian Inspectorate for Environmental Protection, Natural Protection and Water Management, Székesfehérvár, Hungary
[3] Budapest Business School, Institute of Methodology, Budapest Hungary
[4] West-Transdanubian Water Authority, Department Kis-Balaton, Keszthely, Hungary
[5] University of West Hungary, Department of Chemistry and Environmental Sciences, Szombathely, Hungary

Abstract

Determining both the temporal and spatial sampling frequencies in surface waters (lakes, rivers) is a high priority. If a lake is sampled too frequently, resources are wasted; however if the sampling is less frequent than needed, then no valid conclusions can be drawn from the data. The chemical and biological data series of the Kis-Balaton Water Protection System (KBWPS) and Lake Velence were examined using variograms to determine an optimal temporal and spatial sampling frequency. In the case of the KBWPS a three-day sampling was suggested instead of the daily resulting in cost reduction. In the case of Lake Velence the variability of certain phytoplankton was so high that even an average 4.5 sampling locations per km^2 proved insufficient to provide a comprehensive data set. Based on the results, it is suggested that measures be taken at both lakes.

Introduction

Two Hungarian lakes were investigated in this study, the Kis-Balaton Water Protection System (KBWPS) and Lake Velence. These two lakes are highly different, although their evolution began in the same geological age. The KBWPS with its artificial reservoirs filters 45% of the water input of Lake Balaton (largest shallow freshwater lake in Central Europe) [1]. Lake Velence (after Lake Fertő) is the second largest natural sodic lake in Hungary [2]. It is a highly protected natural heritage area with its wetland habitat and many rare species. In the protection and conservation of the ecological state of any natural area (surface water), temporal and spatial sampling frequency is a key question. If a surface water is sampled too frequently in time or space, resources are wasted and the natural environment is needlessly disturbed; however, if the sampling is less frequent than needed than no valid conclusions can be drawn from the data, and again resources go to waste because the data set obtained does not measure up to the desired quality.

Since monitoring began in the late seventies on both lakes the sampling frequency and the location of the sites have both changed many times. Nowadays because of the economic crisis governments are forced to cut spending everywhere possible so today optimizing surface water quality monitoring systems is of even greater interest. In the case of the KBWPS the main question was: Does the possibility exist of rarefying daily sampling in order to reach higher cost efficiency; while in the case of Lake Velence the aim was to determine whether the current sampling grid is sufficient and where could it be changed.

Materials & Methods

Since the needs of temporal and spatial sampling frequency estimations are different, different types of datasets were used during the analyses. In the case of temporal sampling frequency estimation annual time series (consisting of daily samples) of the KBWPS were split into summer and winter data (1993-2007). As a result 216 time series were obtained for total nitrogen (TN) and total phosphorus (TP; mg l^{-1}) (the parameters mostly responsible for eutrophication) from four sampling locations. In the case of spatial sampling frequency estimation the analysed dataset was obtained from a sampling programme conducted on 116 sampling sites of Lake Velence between 4-7 July 1995. Many physical, chemical parameters and phytoplankton were measured. There has not been any other study in Hungary, which included the sampling of phytoplankton in measuring the variability of sampling sites. Naturally enough not every algae taxon of the phytoplankton was observable at all of the sampling sites, so only those were chosen to be a part of the study which appeared on at least 80 sampling sites. The method applied was variogram (Fig. 1) analysis [3] the basic tool in geostatistics [4].

Results

Regarding the KBWPS, based on the results obtained from the TP and TN parameters, a three-day sampling frequency was suggested instead of the present daily. Since trophic conditions are of great importance, from the many examined parameters phytoplankton was chosen, and specifically *Chrysoflagellata sp.* is presented here. In Lake Velence the spatial variability of phytoplankton is generally high. In most of the cases where a range was determinable it was estimated at approx. 400 m, however there were certain taxon where the variability was lower, in the case of the *Chrysoflagellata sp.* a 480 m range was determined (Fig 1.).

Conclusions

Based on the results, the sampling frequency of TN and TP parameters (which the nutrient loads of Lake Balaton are calculated from) can be rarefied from daily to every three days. As a result an approx. 50% cost reduction may be achieved without rarefying the number of spatial sampling locations. In case of Lake Velence the spatial sampling frequency estimation results indicated that the current four are insufficient; the minimal number of sites for phytoplankton measurements is six. This is only true for the larger open areas; if the whole fragmented water space is to be measured then many more sampling sites are needed.

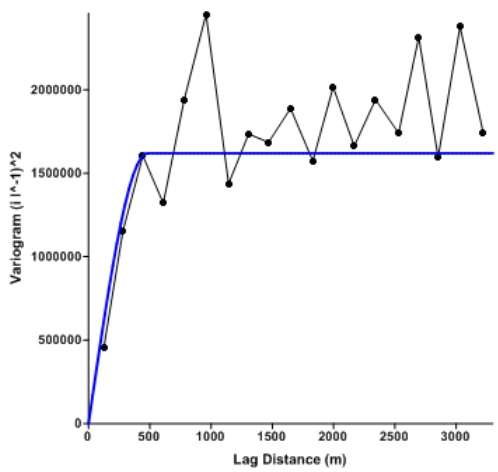

Fig. 1; Variogram of *Chrysoflagellata sp.* indicating a 480 m spatial range

References

1) I.G. Hatvani, J. Kovács, I. Kovácsné Székely, P. Jakusch, J. Korponai, Analysis of long term water quality changes in the Kis-Balaton Water Protection System with time series-, cluster analysis and Wilks' lambda distribution, *Ecol. Eng.*, 37(4), (2011) 629-635
2) G. Lakatos, M. Kiss, I. Mészáros, Heavy metal content of common reed (*Phragmites australis*/Cav./Trin. ex Steudel) and its periphyton in Hungarian shallow standing waters, *Hydrobiologia*, 415, (1999), 47-53
3) J. Kovács, I.G. Hatvani, I. Kovácsné Székely, P. Tanos, J. Korponai, Key question of sampling frequency estimation during system calibration, on the example of the Kis-Balaton Water Protection System's data series, *Georgikon for Agriculture*, 14(1), (2011) 53-68
4) R. Webster & M.A. Oliver, *Geostatistics for Environmental Scientists* Ed. G.B.M. Heuvelink, (2009), ISBN 9780470517277